External Independent Peer Review by the Center for Independent Experts

Panel Review of an Acoustic-Trawl Method for Surveying CPS
Southwest Fisheries Science Center
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1. Executive Summary

The Chair initiated the panel discussion by identifying six key issues that provided a focus for discussion during the review:

(a) design of the acoustic and trawl sampling, including the representativeness of the data for the four coastal pelagic species (CPS);

(b) analysis of the survey data for estimating CPS abundances;

(c) evaluation of potential biases in sampling design and analysis;

(d) characterization of uncertainty in estimates of CPS biomass;

(e) decision if acoustic-trawl estimates of CPS biomass can be used in stock assessments and management advice for Pacific sardine, jack mackerel, Pacific mackerel, and northern anchovy, and;

(f) guidance for future research.

Dr Kevin Hill, SWFSC, presented the most recent Pacific sardine stock assessment, and thus updated the Panel on important issues for CPS assessments and management. Dr David Demer, Leader of the Advanced Survey Technologies Program (ASTP), SWFSC, gave a presentation of the acoustic-trawl method for assessing CPS, and this was followed by responses to several requests by the Panel for additional information.

The collected data from the survey also provide useful information on ecosystem properties as well as fish behaviour. In a dynamic system like the California current, ecosystem and fish behaviour properties information is important for understanding shifts in species composition and relations among species that are recorded in the surveys.

The ASTP provided detailed background material with a very competent evaluation of methodologies and results. Further, their willingness and capability to respond to the Panel requests enhanced the efficiency of the Panel. It became clear that the ASTP team had already identified most of the issues identified by the Panel and had prepared information pertinent to these, which helped the Panel in its deliberations. The work related to avoidance of CPS to vessels was particularly helpful for drawing conclusions related to whether avoidance, or at least its effects on the acoustic-trawl survey results, is likely substantial.

In summary, the acoustic-trawl surveys, as well as the methods of data collection and analysis, are adequate for the provision of advice on the abundance of Pacific sardine, jack mackerel, and Pacific mackerel, subject to caveats, in particular related to the survey areas and distributions of the stocks at the times of the surveys. Most importantly, the estimates from the acoustic-trawl surveys can be included in the 2011 Pacific sardine stock assessments as 'absolute estimates', contingent on the completion of two tasks, and estimates of jack mackerel and Pacific mackerel may also be useful in stock assessments and management. However, given the current size and abundance of the northern anchovy stock(s), the present surveys cannot provide estimates of their abundance(s) for use in management. The acoustic-trawl method could potentially be applied to survey CPS currently in low abundances, e.g., northern anchovy and Pacific herring, but only if the sampling design take into account the distinctiveness of these stocks' distribution and biology. In particular it should be noted that the survey effectiveness could change considerably if/when the species composition among the CPS changes. A strategic interaction between the ongoing aerial survey and the acoustic-trawl survey could potentially facilitate a monitoring less sensitive to the impacts of the environment on distribution and abundance of the CPS.

2. Background

The National Marine Fisheries Service's (NMFS) Office of Science and Technology coordinates and manages a contract providing external expertise through the Center for Independent Experts (CIE) to conduct independent peer reviews of NMFS scientific projects. A Statement of Work (SoW) described herein was established by the NMFS Project Contact and Contracting Officer's Technical Representative (COTR), and reviewed by the CIE for compliance with their policy for providing independent expertise that can provide impartial and independent peer review without conflicts of interest. CIE reviewers are selected by the CIE Steering Committee and CIE Coordination Team to conduct the independent peer review of NMFS science in compliance the predetermined Terms of Reference (ToRs) of the peer review. As a CIE reviewer I am contracted to deliver an independent peer review report to be approved by the CIE Steering Committee and the report. Further information on the CIE process can be obtained from www.ciereviews.org.

As an expert in acoustic-trawl survey methodologies, I was selected to serve on a Panel to evaluate an acoustic-trawl method for surveying coastal pelagic species (CPS). The SWFSC's Fisheries Resources Division (FRD) has explored the use of acoustic-trawl methods, which are commonly used by other regions and countries to estimate the abundances and distributions of CPS in Californian waters. Acoustic-trawl methods may provide a more robust (i.e., accurate and precise) and efficient means to routinely survey the Pacific sardine populations as well as the populations of jack mackerel, Pacific mackerel, and northern anchovy. FRD has conducted acoustic-trawl surveys off the U.S. west coast, from the Mexican to Canadian borders, and developed methods for estimating the abundances and distributions of CPS from these data. The data are used in analytical stock assessment. This review covers the acoustic-trawl survey design and analysis methods, documents, and other pertinent information for acoustic-trawl surveys of Pacific sardine, Pacific mackerel, jack mackerel, and northern anchovy. The confinement of the stocks within the survey area compared to inshore-offshore areas, as well as north into Canada and south into Mexican waters, are important design issues. Trawl sampling and the evaluation of uncertainty including behavioural aspects impact on survey results are important issues of the review.

3. Description of the Reviewer's Role in the Review Activities

My focus of research is presently related to acoustic- trawl survey methodologies. Behavioural impacts on assessments of fish stocks from surveys, acoustic as well as trawl surveys, have been an important part of my experience. My practical experience comes from assessment surveys, stock assessment working groups, and the responsibility of a large number of experiments for assessing quality of scientific surveys. I have field experience from European coastal waters as well as from deep waters in the mid-Atlantic and in the Vietnam-Thailand-Malaysia area. I have worked at the demersal fish department at the Institute of Marine Research, and served as section head at the pelagic fish department. In 2002 I started building a new research group in survey methodology. Presently I am chairing a new international initiative in marine ecosystem acoustics. My main research interests include acoustic-trawl survey methodology, fish behaviour, biophysical interaction, and fisheries induced evolutionary changes. My work has been presented in about 70 publications in peer-reviewed journals, and, in addition, several book chapters and a number of technical papers and reports. I have served on the board of four research programs of the Research Council of Norway, have been a member of the scientific steering committee of Census of Marine Life and have also been a member of a SCORE WG in observation methods. I have also been a member of several working groups under the International Council of the Exploration of the Sea.

Prior to the review meeting, I responded on requests from the CIE office. I had access to most of the review material and prepared for the meeting by reading the material. The main activity was participation in the panel meeting and the associated discussions and reporting. After the meeting, I repeatedly read and commented on the panel chair's updated versions of the panel review report. My particular emphasis was on impacts on behavioural aspects on survey results. This includes aspects of the survey design (coverage), species compositions, trawl sampling and fish avoidance. Final activity included the preparation of this report.

4. Summary of Findings

4.1 ToR 1 – Review of reports

Review documents detailing acoustic-trawl survey and data analysis methods and results according to the PFMC's ToR for CPS Stock Assessment Methodology Reviews. Document the meeting discussions. Evaluate if the documented and presented information is sufficiently complete and represents the best scientific information available.

There were two prime documents available for review before the meeting started: 1) Acoustic-trawl survey --- methods and examples, and 2) Acoustic-trawl survey --- Estimation of distribution and abundance in the spring. In addition, 22 other papers and reports were provided as background information (all documentation is listed in Appendix 1).

The presentations at the meeting started with Dr Kevin Hill, SWFSC, who gave a brief summary of the most recent Pacific sardine stock assessment to orient the Panel on important issues for CPS assessments and management. Dr David Demer, Leader of the

Advanced Survey Technologies Program, SWFSC, gave a presentation on the acoustic-trawl method for assessing CPS, and this was followed by responses to several requests by the Panel for additional information. The primary papers along with the presentations gave an informative documentation of the survey methods along with the traditional assessment of the stocks in question. Further, information on the environmental and ecological background of the area and the challenges associated to the acoustic-trawl assessment was provided. The papers and presentation also highlighted the dynamics of the ecosystem that may involve change of species dominance over relatively short periods of time.

The presentation and the responses to questions and request for further analysis were impressive and revealed a team with high scientific standards and demonstrated a thorough preparation for the review. After the presentation the panel put forward a number of questions that either was clarified directly or specified for further analysis. These requests were answered the next day.

Survey reports:
The methods reporting was split in a survey method report (Part 1) and a report on experience (Part 2). This separation was a useful way of giving insight in the basic methodologies and how it can be applied.

The methods report (Part 1) gives a solid documentation of the work done to secure good practice in a routine survey. This is particularly valid for the acoustic evaluation where the authors document routines for objective evaluation of the acoustic records (VMR filtering). Some specific comments on the documentation of some key issues that could have been improved:

1. TS – in lack of *in situ* TS measurements, available measurements from similar species in other areas are used. Changes in TS due to depth, season and condition (Ona, 2003) are not considered.
2. The documentation of sampling gear and its efficiency is limited. As sampling has a crucial impact on the abundance estimates documentation, e.g. as trawl drawing and rigging should be provided as an appendix.

The experience report (Part 2) provides a pertinent overview of results when applying the methods described in Part 1. The figures and table present the essential information for evaluating the results. Some important details seem to be lacking, and this has an impact on the evaluation of the results:

1. The length compositions are not included but the reader is referred to another report. Length information should be available as it has a crucial impact on the results.
2. As vessel avoidance is a much debated issue, the results might be affected by the fact that many vessels are involved in the surveys. Noise measurements or some kind of intercalibration would be preferable. The reader has no way of evaluating the vessel effect. At least vessel sizes and horse powers should be specified.
3. Calibration results should be presented in a way that allows for a comparison among surveys.

Of the additional reports presented I would like to mention the aerial survey (Jagielo *et al.,* 2009, background information) demonstrating that visual techniques may provide useful information about the CPS. As this survey method collected data that are complementary to the acoustic-trawl survey, it produces an important source of information that might shed light on, even in quantitative terms, vessel avoidance and availability issues.

In conclusion, the acoustic-trawl survey reports are well prepared and the competent presentation gave an excellent background for the discussion of the quality and performance of the acoustic – trawl survey.

4.2 ToR 2 – Evaluate and provide recommendations on survey methods

Evaluate and provide recommendations on the survey method used to estimate the abundances and distributions of Pacific sardine and other CPS, and associated sources of uncertainty. Recommend alternative methods or modifications to the proposed methods, or both, during the Panel meeting. Recommendations and requests to FRD for additional or revised analyses during the Panel meeting must be clear, explicit, and in writing. Comment on the degree to which the survey results describe and quantify the distributions and abundances of CPS, in particular Pacific sardine, and the uncertainty in those estimates. Confidence intervals of survey estimates could affect management decisions, and should be considered in the report.

4.2.1 Survey design and area coverage

Surveying dynamic pelagic stocks in a dynamic ocean environment requires a survey and sampling design that takes appropriately into account the distribution and migration patterns. Ideally, the surveys should cover the entire ranges of all four species, and sampling should be designed to provide representative information (acoustic and trawl) within the surveyed area. In practical terms compromises have to be made. The issue here is if the current survey design and allocation of sampling effort spatially meet the objectives of the survey.

The design utilizes the existing egg surveys for both spatial coverage and collection of trawl data. Thus, there is no explicit design to meet the acoustic-trawl survey. As the survey transects are more or less regularly spaced, the design meets normal standards for such surveys. Also, some adjustments are done in areas according to expected abundance. Abundance is estimated by equal weight of transect abundances within strata and variance by bootstrap.

The design assumes distribution of fish within 70 m depth and presumes that the major part of the biomass is deeper than the transducer depth. The survey vessels run transducers with different depth. This might introduce a vessel effect. Although there is no information indicating a large impact of vertical distribution on the available survey results, annual changes in vertical distribution could introduce both a vessel bias and an overall underestimate of abundance.

Some selected aspects are discussed in the following:

The design and approach take for the CPS survey seem appropriate and at present there exists enough evidence to state that some fish, but not a critical amount, are located

outside the survey area. The preferred habitat method should be further explored to ascertain its validity for stratification of the survey effort over time. Further, other information, including information from the commercial fisheries, should be studied in an effort to enhance the use of the limited survey effort. The design would clearly need to be changed if useable estimates of abundance for northern anchovy (and Pacific herring) are needed, given the current size and distribution of these species. The abundance of CPS species fluctuates over time and that the optimal survey design may need to change over time (e.g. if anchovy should increase substantially in abundance). Further work would be required to determine if stratification would be successful, or if a uniform spatial distribution of effort is required. The whole issue is determined by the objectives - if the survey is to be single species, multispecies or to have an ecosystem focus. A dynamic and variable distribution by the various species will also affect impact of distribution outside the area covered by the present survey. Will the survey design be able to pick up this variability? We were informed that transects were continued, when possible, to the zero distribution line offshore. The analyses of the potential biases caused by lacking or variable coverage seem appropriate and should be continued. Prediction of preferred habitat (Zwolinski *et al*., 2011, background information) demonstrates a way of enhancing/optimizing survey design. The robustness of the survey design and habitat prediction method for substantial changes in abundance and distribution is still unknown. I think that there are good reasons to believe that the properties and relationships, including preferred habitat, estimated during this study period might change periodically similarly to what is seen in other large pelagic stocks (see e.g. Holst *et al.,* 2006). Particularly, such changes will probably take place when the substantial changes in the CPS species' compositions and abundance take place and the need for reliable survey results are highest.

Recommendations: Further development of the habitat prediction approach and use of auxiliary information, e.g. distribution from an aerial survey could enhance efficiency of the survey design and minimize impact of temporal changes in distribution (vertical and horizontal) and migration patterns.

4.2.2 Trawl sampling

The acoustic-trawl survey utilizes trawl samples designed for the simultaneous egg survey. These samples are needed for species and size compositions in the estimation of TS, abundance and biomass. The approach is contrasted with a most common approach which applies targeted sampling on recorded echo traces.

The strategy as presently applied works well under homogenous situations. The problem with the current approach might occur when the survey area has many species with different acoustic properties, inhomogeneous distribution and varying behavioural characteristics. The problem might affect estimation of **stock properties** and **estimates of uncertainty.**

The CPS survey covers several pelagic species which demonstrate large variability in abundance and distribution over time. A potential concern with the trawl sampling is that there may be species and size selectivity. At present, there appears to be considerable spatial separation among CPS species, especially during the summer survey, indicating that species proportions are relatively well established. Although night time catch rates may not fully match daytime observations, it might be considered a minor issue for Pacific sardine and jack mackerel because the areas occupied by these

species are generally homogeneous. Size separation by depth is not studied and this could complicate the sampling issue and comparability day/night. There is a need to test the assumption of spatial homogeneity.

Recommendations: Increased effort will be required in areas dominated by the less abundant species if useable estimates of abundance are needed for the full range of all species. It is possible to study species selectivity effects by comparing the ratio of catch rates and acoustic abundance in areas where single species dominate. To clarify size composition issues depth stratified sampling could be conducted. In the longer term, efforts should be made to evaluate if different fishing practices / gears would be beneficial. The objective would be to deploy a gear with the potential for daytime fishing and direct species identification of schools to support acoustic identification to the species level.

4.2.3 Allocation of effort between trawl and transect data collection

Balancing effort in biological and acoustic sampling is a critical issue for survey assessment quality. In this case, the balance is determined by the needs of the simultaneous egg survey. Although this balance appears to be adequate at present, the design is rigid and does not allow needed flexibility for biological sampling. The current variance estimation procedure could be utilized to investigate an optimal sampling strategy in terms of variance in the estimated biomass. Some studies (e.g. Simmonds and MacLennan, 2005; Simmonds *et al*., 2009) suggest that a broad range of time allocations lead to similar overall variance estimates, which indicates that optimization of the time allocation may not be a critical issue.

Recommendations: Allocation of effort is probably fine. Flexibility in sampling, allowing opportunistic sampling according to acoustic registration, is, in most acoustic surveys, an important practice to detect changes in distribution patterns by size or species and should be aimed for in CPS surveys in the future.

4.2.4 Multiple vessel

The use of multiple vessels in standard assessment surveys may add complexity to the interaction between the observer and the observed. Current surveys were conducted using four vessels ranging from 41 to 65 m in length, with displacements ranging at least two fold. Such differences require consideration of the following issues:

- Vessel noise may potentially affect fish behaviour during surveys. Fish may avoid the sound source, either by diving or moving to the side, or both. Such behaviour may lead to reduced fish density under the transducer during the moment of recording. Furthermore, TS might change as a result of changing fish tilt angle during the avoidance response, thus impacting, in most cases reducing, estimates of density. Some studies (e.g. Dagorn *et al*., 2001; Røstad *et al*., 2006) suggested that vessels may attract fish, thus increasing densities measured by acoustics. The International Council for the Exploration of the Seas (ICES) has therefore recommended using noise-reduced vessels to reduce these potential impacts.
- Other parts of the sound spectrum, particularly infrasound, also appear to be responsible for changes in fish behaviour in response to survey vessels. This implies that noise as measured by the ICES standard (Mitson, 1995) does not necessarily reflect the strength of the vessel's avoidance stimulus. Rather, the

stimulus may be more associated with the size of the vessel and its displacement than the noise emission.
- Visual stimuli may attract fish similarly to a FAD (Fish Aggregating Device) and will affect observations in shallow water and at short distances from the vessel.

Further complexity in potential fish behaviour is caused by interactions among the above sources. This is reflected in the literature as large variability in the observed responses of fish to survey vessels. In the present case, the vessels vary substantially in size and horse power and have different propulsion and noise-reducing arrangements. The potential exists for vessel-specific impacts on the survey results if the target species are sensitive to any of the stimuli described above (Hjellvik *et al*., 2008). As an example, the FV *Frosti*, which is considered a noisy vessel by the Team, recorded fish closer to the surface than the other vessels. If vessel noise represents the stimulus, it could signify a vessel avoidance effect. On the other hand, *FV Frosti* is the smallest ship (least displacement) and the vessel difference could be due to infrasound impacts from the larger vessels (Ona *et al*., 2007; Sand *et al*., 2008).

Recommendations: To avoid vessel effects it is an obvious advantage and a general recommendation to use same vessels over time. Appropriate noise measurements and intercalibration are recommended when various vessels are used, as in the present case. Dedicated studies of avoidance behaviour should be carried out (see 4.2.8).

4.2.5 Timing of acoustic and trawl sampling

Pelagic species are known to have diel and seasonal behavioural characteristics which can have large impacts on survey results. These characteristics may influence the results due to variations in the availability of the fish to acoustic sampling as a result of their vertical and horizontal movement. The acoustic sampling occurs during the day when the CPS are typically aggregated deeper, and trawling occurs at night when the CPS are typically dispersed near the surface. The current trawl and vessel configurations have been generally unsuccessful catching schooling fish during the day. Conducting acoustic sampling during the day and trawling at night is a reasonable approach because the available effort is used efficiently, and available analyses comparing distributions of CPS backscatter with length and species distributions from the trawls indicate that present procedures produce estimates that reflect the true properties of the stocks. Nevertheless, validation of CPS backscatter to species and size should be improved through targeted trawl sampling.

It is particularly noted that the trawl catches are small compared to those in many other acoustic-trawl surveys, which raises the question whether trawl catches are representative of the populations. I, therefore, recommend further investigation of how trawls are allocated to acoustic signals, for example, by conducting sensitivity tests in which stations are pooled and allocated to acoustic values over a larger area.

Recommendations: In the longer-term, it is ideal to have a trawl and vessel configuration that can support targeted trawl sampling. This would increase the number of samples, and enhance the representativeness of the trawl samples to species and their sizes in the populations sampled acoustically. Also, repeated trawl sampling experiments could lead to a better understanding of small-scale variability and could

improve the sampling design as well as enhance understanding of the uncertainty in the survey estimates.

4.2.6 Trawl design and operation

Trawl efficiency depends on the interaction between trawl design and fish behaviour. This causes size- and species-selectivity due to: (a) fish avoiding the trawl before entering the net (potentially size- and species-dependent); (b) fish escaping through the meshes near the mouth of the net; and (c) fish escaping through the meshes in front of the codend. The latter problem is particularly probable if there is a large change in mesh size from the trawl to the codend and the net is towed at a high speed. If pelagic species exhibit schooling rather than individual behaviour, these problems may not be significant. However, the low trawl catches may indicate individual behaviours of the fish during the trawls, which could influence species and size selection. Species-related behavioural characteristics influence trawl selectivity and may affect estimates of species proportions in areas where they are mixed. This is a problem for trawl sampling in general. For the survey and sampling design used here, the available information indicates the trawl to be adequate, but the small catches call for further studies, likely leading to improvements to the trawl sampling.

The available drawings of the Nordic trawl indicate that it is used with a small-mesh and short codend, and the change in mesh size from the codend to the trawl is large. This could cause the so-called "bucket effect". This is partly documented and partly anecdotal information and concerns the heavy loss of fish in front of the codend due to combination of trawl design and trawling speed. In such cases, fish might swim in the transition zone between the codend and the trawl, and escape through the trawl meshes, and cause size and species selection (see e.g. http://www.worldfishing.net/features101/product-library/fish-catching/trawling/increasing-efficiency-in-pelagicsemi-pelagic-trawling; Wardle *et al*., 1986; Fernoe and Olsen, 1994).

Recommendations: There is a need to have the design evaluated by experts in trawl design to make sure that the gear and fishing protocols are aligned with the survey objectives. Simple adjustments, e.g., increasing total length and mesh size of the codend and the extension piece could mitigate the identified potential problems. Over the long-term, the efficiency and selectivity of the trawl could be tested by comparing samples from same area taken with the survey trawl and a purse seine. Further, state-of-the-art acoustic and optic technology allows direct observation of trawl efficiency by observing fish behaviour and escapement at various critical positions of the trawl. Thus, I recommend that such approaches should be pursued and that, in the long-term, trawl and vessel configurations be used that enable direct sampling of pelagic schools.

4.2.7 Acoustic equipment specifications

The survey applies state of the art echosounding technology with multiple frequencies Simrad EK 60 as the main tool. The survey team has developed new innovative filtering routines utilising the multiple frequency system, and much work has already been done on utilising the variation in backscattering by frequency, and there is still further potential in this technique. This avenue need to be pursued further.

Due to the fact that fish are distributed close to the vessel, a higher ping rate than the one applied might have given better resolution of schools for the characterisation of distributional, ecological and behavioural properties important to the survey results.

Complementary sensors were used for behavioural studies including multibeam systems. Such instrumentation is useful for studying avoidance reactions to vessel and trawl (Ona *et al.,* 2007). Behaviour of fish in relation to water currents could be obtained from data produced by ADCP. We were informed that new advanced sonars (Simrad MS/ME 70) will be available in the near future. These will give new opportunities to study fish in the upper part of the water column.

The acoustic specification is appropriate for abundance estimation, noting that a layer near the surface is not sampled. However, the acoustic sampling may not be adequate for research on school characteristics and a description of the global pelagic ecosystem.

Recommendations: The following should be considered: (a) develop routines for using new sonar technology (MS/ME 70) when these become available to quantify abundance and vessel-induced behavioural effects of near surface fish; (b) continue to work on definition and precision of the VMR process; (c) use a higher pingrate to improve resolution of fish close to the vessel; and (d) continue development of methods that categorize the acoustic records and thus support automatic species identification, following existing methodologies (e.g. Haralabous and Georgakarakos, 1996; Korneliussen and Ona 2000; Lawson *et al*., 2001; Kloser *et al.* 2002).

4.2.8 Vessel avoidance

Fish response to vessel passage has been documented for small pelagic species in other areas (e.g. Freon and Misund, 1999). There is a potential for bias in abundance estimates from acoustic surveys if vessel passage causes fish to change their orientation in the water column, or exhibit some kind of consistent movement, either avoidance or attraction. Echosounders used in the CPS acoustic-trawl survey are mounted in the centre of vessel and are effectively deeper than approximately 3.75 m and extend to 10 m. Sardine, in particular, are often found near the surface at least at some times of the year, and fishermen have noted strong avoidance responses to vessel passage. This is a critical issue to address when deciding how or whether to use the abundance estimates based on acoustic-trawl data for stock assessment.

The influence of fish avoidance has been investigated using two approaches: (a) the distribution under and to the side of the vessel was examined using multibeam sonar, and (b) volume backscattering (S_v; dB re 1 m^{-1}) of fish schools observed in successive pings was examined to test the hypothesis that a vessel impact would lead to a reduction in S_v and an increasing average depth during passage. Studies with similar equipment on European pilchard in the Mediterranean Sea show increased schools off track (Soria *et al*., 1996), while Chilean sardine in contrast showed no increase in schools off track (Gerlotto *et al*., 2004). In most cases for CPS in the CCE there was little evidence for differences in depth or backscatter from the front to the end of schools, suggesting that any diving behaviour takes place before the school passes through the acoustic beam, although a minor diving apparently was noted when schools were shallow. There is limited evidence for avoidance. School counts showed a sharp peak under the vessel, and a steady reduction with distance away from the vessel track and depth, suggesting no increase in schools off track, as might be expected if there were lateral movement in response to the vessel. Additionally, the maps of CPS observed acoustically and caught

in trawls were qualitatively in agreement. The contrasting evidence of strong avoidance experienced by fishermen might be caused by learning; fish being hunted are more reactive than those not.

It is concluded that, based on the information presented during the meeting, vessel-induced behaviour, including vessel-specific behaviour, appears unlikely to have a substantial effect on the estimates of CPS biomass during the current surveys. However, it is noted that the results related to the potential for lateral avoidance are somewhat difficult to interpret without reference to expected patterns under alternative hypotheses of fish response. Nevertheless, they do not suggest large avoidance effects.

Recommendations: Although vessel avoidance has been studied using adequate methods and there was no evidence for substantial avoidance effects, the issue warrants further study. For example, variation in vessel size (41m – 65m) and survey speed (11-14 knots) calls for further, follow-up studies. Future studies should resolve the information by species and address the possibility of spatial and temporal variability in vessel effects.

- The frequency response of schools should be studied for trends versus depth utilising frequency dependent directivity (Godø *et al.,* 2006). A change in fish tilt angle due to vessel-induced avoidance will affect higher frequencies more than lower frequencies. The frequency response may change versus depth if avoidance behaviour diminishes with depth beneath the vessel.
- Differences in the transducer beamwidths (12^o for the 18 kHz transducer versus 7^o for the other frequencies) could be used to observe fish diving beneath the vessel. The wider beamwidth will be less sensitive to changes in fish orientation than narrower beamwidth. Thus, an avoidance reaction may be indicated if depths measured at the top of schools are shallower in the 18 kHz recordings compared to the other frequencies.
- Long-term research should use more advanced instrumentation and methods for studying potential vessel effects and avoidance. Over the long term, vessel by vessel studies following the model of the Bering Sea comparative studies, should be conducted.

The sophisticated multibeam systems (Simrad MS70 and ME70) (Ona *et al.,* 2006) will be available on the new SWFSC vessel in near future. This represents state-of-the-art instrumentation to clarify issues related to school behaviour in the vicinity of the vessel and should be fully utilised to clarify vessel impact factors. Presently, not all vessels have been noise measured according to the ICES standard. Standard vessel noise measurements should routinely be conducted to allow comparison of stimuli and fish reactions to allow vessel comparisons in the future.

4.2.9 Target strength

Target strength is a key property in acoustic-trawl surveys, but is the basic formula used here appropriate for giving reliable survey estimates?

No, *in situ* target strength measurements are available for CPS in the CCE. Used instead are published TS versus length relationships for the same or similar species in other ecosystems. While this substitution is not ideal, such TS estimates likely do not have a large impact on abundance estimates. The largest error may result from the use of

Chilean jack mackerel, with specific swimbladder properties (Peña 2008), as TS for Pacific mackerel.

Recommendations: *In situ* CPS TS measurements are difficult to obtain, but effort should be made in future CPS acoustic-trawl surveys; for example, using alternative platforms (Johansen *et al.,* 2009). Alternative approaches such as school capture with purse seine, inference from models and multi-frequency observations or *ex-situ* methods should be explored. The impact of errors in the TS could be elevated and become detrimental to assessment if distribution patterns of the various species change with higher degree of mixing. It is also known that TS might vary by season, depth and condition. Modelling TS taking this into account should be a goal for the future (see Ona, 2003).

4.3 ToR 3 – Evaluate and provide recommendations for the application of these methods

Evaluate and provide recommendations for the application of these methods for their utility in stock assessment models and for their ability to monitor trends at the population level for Pacific sardine and other CPS. Survey methods or results that have a flawed technical basis, or are questionable on other grounds, should be identified so they may be excluded from the set upon which stock assessments and other management advice is to be developed.

Application of the acoustic – trawl survey in stock assessment

The applicability of the survey data in assessment is totally dependent on its quality (as discussed above) and consistency over time and among species. I concur with the rest of the panel on the quality of the survey methods and the collected data. When it comes to consistency of the data over time, the time-series are short and are difficult to evaluate. Often, inconsistency in time series becomes apparent when stocks are passing through recruitment cycles or other natural variability. My limited experience with the stock assessment model used in this case prevents me from giving specific comments directly related to assessment models.

The most apparent finding is the discrepancy among the involved species. The focus of the survey has been on Pacific sardine, and the quality and appropriateness for the other species are limited by their geographical distribution or variability. Not unexpectedly, there was less information for the other species; hence, in contrast to Pacific sardine, it was more difficult to reach definitive conclusions for jack mackerel, Pacific mackerel and northern anchovy

Pacific Sardine

Pacific sardine are an actively-managed CPS species. Given the relatively short time-series of abundance estimates, inclusion of the acoustic-trawl data as relative indices of 1+ biomass would likely not impact the assessment results substantially (but this should be examined in the assessment). The low fishing mortality increases demand for fisheries independent data. I consent that including the sardine estimate as an absolute estimate is appropriate for the upcoming stock assessment in September 2011. The major potential sources of uncertainty related to using the acoustic-trawl data as estimates of absolute abundance identified during the review are:

- The relationship between TS and length are not based on *it situ* measurements, but are taken from a different area.
- Sardine may avoid the vessel to some extent.
- Sardine are found outside of the area covered by the acoustic transects (north, south, offshore and inshore), with the proportion of the stock outside this area depending on season as well as environmental conditions.

Although these uncertainties seem limited at the time being, these are all reasons to closely follow up each of the issues to secure stability over time. In particular, all effort should be taken to minimize the impact of fish distributed outside the survey area by reanalyzing the auxiliary information (e.g., trends in density along transects, information from ichythoplankton surveys south of the survey area, and catch information).

Jack mackerel
Jack mackerel are a monitored CPS species. This is a data poor stock and the survey information is thus an important source. Being of limited abundance compared to sardine creates additional uncertainty of larger importance to jack mackerel than for sardine. Particularly, the catchability of jack mackerel could be considerably different from sardine. This suggests that the summer survey might be the most appropriate as this is the time with the highest degree of separation. To conclude, as the survey estimates are the only relevant estimate, the estimates should be considered as estimates of absolute abundance and biomass of jack mackerel for the survey area in US waters (and the estimate for summer may therefore be more reliable).

Pacific mackerel
High variability (CV) and unknown and variable amount of fish outside the survey area suggest that these data should be used with great caution. At present, the Pacific mackerel data appears inappropriate to be included in a stock assessment model.

Northern anchovy
This species has another distribution and behaviour compared to the other CPS. This should not prevent the acoustic – trawling survey method from being adequate for giving reliable estimation of abundance. As the stock is small and fragmented in inshore areas, it is not properly covered by the present survey design. The available information is not recommended to be used in stock assessment models.

4.4 ToR 4 – Evaluate the effectiveness of the survey methods

Evaluate the effectiveness of the survey methods for detecting the appropriate spatial scale and seasonal timing for annually estimating stock abundances.

Pacific Sardine
Anecdotal and fisheries information indicates that Pacific sardines are distributed outside the survey area. This is documented by the Mexican and the Canadian surveys. Also, Canadian fishermen claim that large catches are taken outside the Canadian survey area (in the inlets). Available analyses indicate that the problem is small but in some surveys possibly substantial. This issue needs substantial attention as it might change from year to year. It is recommended that analyses using auxiliary information, including data from fishermen, are intensified. If possible, systematic collection of such information about distribution both outside and during the time of the survey should be done. At present, it is reasonable to state that the acoustic-trawl surveys can be

considered as providing estimates of distribution of abundance for the survey area. To conclude, it is expected that the area surveyed covers the majority of sardine at the time of the survey. The distribution dynamics over time and space, as described in the primary documents, suggest that analysis of distribution changes and survey coverage should be routinely done as a part of the survey stock assessment.

Jack mackerel
The jack mackerel acoustic-trawl survey estimates are the only quantitative scientific information about this stock. A major part of the uncertainty of this stock arises probably due to distributional uncertainty. Even though less information is available for jack mackerel, the geographical information obtained from the survey is important. Over the years, the spatial and temporal distribution might give a more comprehensive understanding of the true distribution pattern. This might also enhance the applicability of the data in stock assessment models.

Pacific mackerel
It is a general concern for this species that a considerable, but still unknown, part of the stock is found outside the survey area. The distribution pattern of the stock within the survey area is probably well reflected. Thus, survey estimates given for the survey are considered valid, but how big the fraction of the stock is remains unknown and might vary from year to year.

Northern anchovy
The anchovy population is currently small and distributed inshore, often in areas not properly covered by the survey. The survey is thus neither expected to reflect the distribution nor the abundance. A few northern anchovy were sampled nearshore, mostly off Oregon and Washington (2006, 2008, and 2010), north of Monterey Bay (2006) and in the Southern California Bight (2006 and 2008). Apart from the occasional large catches (~ 300kg) off the mouth of the Columbia River and other likely locations such as off Santa Barbara and Monterey Bay, anchovy were scarce in these surveys, even off southern California where they once were the most abundant species. If the anchovy population should be properly covered, the sampling design would need to be considerably modified.

4.5 ToR 5 – Decide through Panel discussions if the ToRs and goals of the peer review have been achieved

Decide through Panel discussions if the ToRs and goals of the peer review have been achieved. If agreement cannot be reached, or if any ToR cannot be accomplished for any reason, then the nature of the disagreement or the reason for not meeting all the ToR must be described in the Summary and Reviewer's report. Describe the strengths and weaknesses of the review process and Panel recommendations.

The review was carried out efficiently with a strong focus on covering all the ToRs. As far as I can see, we went through materials that elucidated all ToRs and recommendations were developed for all of them. The atmosphere during the discussion was good and creative. Occasionally, when disagreement surfaced, we were given enough time to cover the subject to a point where agreement was obtained. This process was run efficiently so that momentum was maintained and progress was not lost in endless discussions.

It is unquestionable that the panel chair, being well prepared and able to separate the important and unimportant issues, should be paid tribute for an efficient meeting and a fruitful process. A second positive source was the Acoustic-Trawl Survey Technical Team, which gave a professional presentation and was very efficient and apt to respond to all requests.

During the preparation phase, I was guided through all the needed paperwork in an efficient way. We had the scientific documentation available in due time although there was some delay due to a misunderstanding regarding the background information on the ftp site.

In addition to the panel and the The Acoustic-Trawl Survey Technical Team, other observers were present, leading to a large number of attendees. This was mostly useful because more information was readily available when needed. On the other hand, some of these participants were not as prepared and focused as e.g. the The Acoustic-Trawl Survey Technical Team, making arguments, presenting opinions and information that were more difficult to interpret.

Altogether, the review was an exciting meeting with a focused discussion moving steadily towards the goal. This made it a nice and educating experience.

5. Recommendations

The recommendations with respect to utilization of survey results in stock assessment:

It is recommended that Pacific sardine acoustic – trawl survey estimates of abundance and biomass are used in the September stock assessment working group as estimates of absolute abundance/biomass

Jack mackerel data show high variability but provide useful information for assessment and monitoring purposes.

Pacific mackerel estimates should be considered valid within the survey area but uncertainty on the distribution and migration over seasons and years creates uncertainty about the representativity regarding the whole stock.

The Pacific anchovy is poorly covered and the data are not appropriate for stock assessment. Adjustment of survey design is needed to enhance geographical coverage.

Further recommendations are organised according to urgency:

1. **Immediate (prior to the next stock assessments)**

a. Analyses should be conducted using auxiliary information (e.g. trends in density along transects, information from ichythoplankton surveys south of the survey area, catch information) to provide best estimates for the biomass outside of the survey area as well as the range of possible biomass levels.
b. The CVs for the estimates need to be modified to fully account for the uncertainty of the trawl data.

2. **Short-term**

a. Investigate ‘gross’ species selectivity effects by comparing the ratio of catch rates. and acoustic density in areas where single species dominate.

b. Conduct sensitivity tests in which stations are pooled and allocated to acoustic values over a larger area.
c. Consult experts in trawl design to evaluate the current trawl design in relation to the survey objectives.
d. Develop methods that categorize the acoustic record, and thus, support automatic species identification and continue to work on definition and precision of the VMR process.
e. Check the filtering algorithm every year to ensure that it is still suitable under changing conditions.
f. Analyze existing data for vessel avoidance:
    a. trends in frequency response over depth strata in schools.
    b. comparing school depths from the 18 kHz and other transducers to examine possible avoidance reactions.
g. Continue to consider the advantages and disadvantages of conducting acoustic-trawls surveys at different times of the year.
h. Evaluate the potential to give age-based abundance or biomass estimates for sardine and consider their utility in the SS3 assessment given the lack of contrast in length-at-age at older ages and the ability to directly estimate total mortality from the survey result.
i. Conduct standard (ICES) vessel noise measurements for all vessels.

3. Long-term

a. Evaluate if differ fishing trawling practices / gears would be beneficial
b. Use a trawl/vessel configuration that can support directed trawl sampling.
c. Conduct repeated trawl sampling experiments to obtain better understanding of small-scale variability.
d. Test the efficiency and selectivity of the trawl by comparing samples from same area taken with the survey trawl and purse seine.
e. Apply state-of-the-art acoustic and optic technology to investigate fish behaviour and escapement at various critical positions of the trawl.
f. Conduct validation tows on various kinds of backscatter to assure that the filtering algorithm is performing as intended to separate out CPS.
g. Make efforts to obtain *in situ* target strength measurements for CPS species in California Current Ecosystem.
h. Focus on utilising more advanced instrumentation and resource-demanding research for studying vessel impacts.

The survey data can be used for other purposes other than estimating stock properties for the assessment and management of the stock. For example, acoustic-trawl data could be used in ecosystem studies and for ecosystem based fishery management. Although this is beyond the scope of the review, the following suggestions can be useful:

- estimate plankton biomass;
- describe the vertical habitat (thermocline, oxycline, currents, plankton, etc.); and
- determine school characteristics (likely to provide information on species and on possible changes in the fish behavior due to environmental variations)
- Utilise the above to better understand and quantify annual changes in distribution patters that influence quality of survey estimates.

6. Conclusion

The review was carried out efficiently and in a productive and stimulating atmosphere.

The scientific information presented for the evaluation panel are of high scientific standard and indicate that the acoustic trawl survey and associated data analysis follow good practice for such surveys.

The survey results for Pacific sardine are adequate as data for the assessment as estimates of absolute of abundance. The survey also describes well the distribution of the stock, although there is a need to monitor changes in distribution that could impact the quality of data as input in assessment.

The results for the other stocks are more variable mainly due to distributional impacts, but the surveys are an important source of information for all due to the general lack of information.

In the background information and in the scientific literature, it is well known that the CPSs vary cyclically in abundance and distribution. I understand that a focused review of the acoustic-trawl survey methodology is needed, but think that the usefulness of the survey and its review in coming years will depend on the survey's ability to adjust design according to the likely changes in distribution and abundance. My personal opinion is that this issue should have been given attention in the ToR of the review. I think the available information could have given useful guidance for a systematic involvement of auxiliary information and active development and integration of other survey information, in particular the aerial survey. Such approaches could have strengthened the long term monitoring, assessment and management goals of the CPS.

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Appendix 1: Bibliography of materials provided for review

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Appendix 2:

Statement of Work for Dr. Olav Rune Godø

External Independent Peer Review by the Center for Independent Experts

Panel Review of an Acoustic-Trawl Method for Surveying CPS

3-5 February 2011

Scope of Work and CIE Process: The National Marine Fisheries Service's (NMFS) Office of Science and Technology coordinates and manages a contract providing external expertise through the Center for Independent Experts (CIE) to conduct independent peer reviews of NMFS scientific projects. The Statement of Work (SoW) described herein was established by the NMFS Project Contact and Contracting Officer's Technical Representative (COTR), and reviewed by the CIE for compliance with their policy for providing independent expertise that can provide impartial and independent peer review without conflicts of interest. CIE reviewers are selected by the CIE Steering Committee and CIE Coordination Team to conduct the independent peer review of NMFS science in compliance the predetermined Terms of Reference (ToRs) of the peer review. Each CIE reviewer is contracted to deliver an independent peer review report to be approved by the CIE Steering Committee and the report is to be formatted with content requirements as specified in **Annex 1**. This SoW describes the work tasks and deliverables of the CIE reviewer for conducting an independent peer review of the following project. Further information on the CIE process can be obtained from www.ciereviews.org.

Project Description: The Pacific Fishery Management Council (PFMC) uses information from surveys to make decisions related to harvest guidelines for managed coastal pelagic species (CPS) (i.e., Pacific sardine and Pacific mackerel) and Overfishing Levels (OFLs) / Acceptable Biological Catches (ABCs) for monitored CPS (i.e., northern anchovy, jack mackerel and market squid). The current assessments for Pacific sardine and Pacific mackerel are based on the 'Stock Synthesis' framework. The assessment for Pacific sardine uses age- and length-composition data from four fisheries, the results from an aerial survey, and measures of female spawning biomass and total egg production (DEPM) from combined trawl and egg surveys, to estimate the parameters of a population-dynamics model. The survey outcomes and hence model-derived estimates of Pacific sardine spawning-stock biomass (SSB) have recently decreased, resulting in dramatically lower harvest guidelines for 2008 and 2009. The Southwest Fisheries Science Center's (SWFSC's) current standard survey covers the 'core' spring-spawning area between San Diego and San Francisco. The exploited stock ('northern subpopulation') is believed to migrate seasonally, potentially from northern Baja California, Mexico in the spring to British Columbia, Canada in the summer. The DEPM is an indirect measure of fish distribution and abundance. As the sardine population recovered from historic lows and recently reoccupied its former historic range, migrating as far north as Canada in the summer, multiple types and more direct estimates of CPS biomass, particularly sardine biomass, may be needed to improve stock assessments.

Three CIE reviewers will serve on a Panel to evaluate an acoustic-trawl method for surveying CPS. The SWFSC's Fisheries Resources Division (FRD) has explored the use of acoustic-trawl methods, which are commonly used by other regions and countries to estimate the abundances and distributions of CPS. Acoustic-trawl methods may provide a more robust (i.e., accurate and precise) and efficient means to routinely survey the Pacific sardine populations as well as the populations of jack mackerel, Pacific mackerel, and northern anchovy. In spring 2006, 2008, and 2010, and summer 2008, FRD conducted acoustic-trawl surveys off the U.S. west coast, from the Mexican to Canadian borders, and developed methods for estimating the abundances and distributions of CPS from these data. The confinement of the stocks within the survey area, compared to inshore-offshore as well as north into Canada and south into Mexican waters is important design issues. Behavioural aspects are also raised as an important impact factor.

The Panel report will be used to guide improvements to the acoustic-trawl survey and analysis methods, the resulting time series of estimates of abundance and distribution for CPS species, and estimates of their uncertainty. The report will also be used to evaluate the appropriateness of using the results from the survey as inputs to the assessment model for Pacific sardine and Pacific mackerel. The assessment models for Pacific sardine and Pacific mackerel will be reviewed by separate Stock Assessment Review (STAR) Panels. However, the report of this Methods Review Panel will be considered by the assessment analysts and STAR Panels.

An overview of the ToRs for the Panel are attached in **Annex 2**. The tentative agenda of the Panel review meeting is attached in **Annex 3**. Finally, an outline of the summary report of the Panel is attached as **Annex 4**.

Requirements for CIE Reviewer: Three CIE reviewers shall participate in the Panel and conduct an impartial and independent peer review in accordance with the SoW and ToRs herein. Three CIE reviewers shall have expertise and work experience in the design and execution of fisheries-independent acoustic-trawl surveys for estimating the abundance of coastal pelagic fish species, and expertise with sardines is desirable. The CIE reviewers shall have knowledge of the life history strategies and population dynamics of coastal pelagic fish species.

Each CIE reviewer's duties shall not exceed a maximum of 14 days to complete all work tasks of the peer review described herein.

Location/Date of Peer Review: The CIE reviewers shall participate as independent peer reviewers during the panel review meeting at NOAA Fisheries, Southwest Fisheries Science Center, 3333 North Torrey Pines Court, La Jolla, California, 92037-1023, during 3-5 February 2011 in accordance with the agenda (Annex 3).

Statement of Tasks: The CIE reviewers shall complete the following tasks in accordance with the SoW and Schedule of Milestones and Deliverables herein.

Prior to the Peer Review: Following the CIE reviewer selections by the CIE Steering committee, the CIE shall provide the CIE reviewers' information (name, affiliation, and contact details) to the Contracting Officer's Technical Representative (COTR), who will forward this information to the NMFS Project Contact no later the date specified in the

Schedule of Milestones and Deliverables. The CIE is responsible for providing the SoW and ToRs to the CIE reviewers (reviewer hereafter). The Project Contact is responsible for providing the reviewer with the background documents, reports, foreign national security clearance, and information concerning other pertinent meeting arrangements. The Project Contact is also responsible for providing the Panel Chair (Chair hereafter) a copy of the SoW in advance of the Panel. Any changes to the SoW or ToRs must be made through the COTR prior to the commencement of the peer review.

Foreign National Security Clearance: When a reviewer who is a non-US citizen participates in a panel review meeting at a government facility, the Project Contact is responsible for obtaining a Foreign National Security Clearance for the CIE reviewers. For the purpose of their security clearance, each reviewer shall provide requested information (e.g., name, contact information, birthdate, passport number, travel dates, and country of origin) to the Project Contact at least 30 days before the peer review in accordance with the NOAA Deemed Export Technology Control Program NAO 207-12 regulations (available at the Deemed Exports NAO website: http://deemedexports.noaa.gov/sponsor.html).

Pre-review Background Documents: Two weeks before the review, the Project Contact will electronically send to each reviewer, by email or FTP, all necessary background information and reports for the review. If the documents must be mailed, the Project Contact will consult with the CIE on where to send the documents. The CIE reviewers shall read all documents in preparation for the review, for example:

- documents on current survey methods, in particular, related to DEPM and aerial surveys of sardine and other CPS;
- document on SWFSC acoustic-trawl surveys conducted between 2006 and 2010;
- documents from past Panels; and
- miscellaneous documents, such as the ToR, SoW, agenda, schedule of milestones, deliverables, logistical considerations, and PFMC's ToR for CPS Stock Assessement Methodology Reviews.

The CIE reviewers are responsible only for the pre-review documents that are delivered to the reviewer in accordance to the SoW scheduled deadlines specified herein. Any delays in submission of pre-review documents for the CIE review will result in delays with the CIE review process, including a SoW modification to the schedule of milestones and deliverables.

Panel Review Meeting: Each CIE reviewer shall participate in the Panel and conduct an independent review in accordance with the SoW and ToRs. **Modifications to the SoW and ToR cannot be made during the review, and any SoW or ToR modification prior to the review shall be approved by the COTR and CIE Lead Coordinator.** Each reviewer shall actively participate in a professional and respectful manner as a member of the Panel, and their review tasks shall be focused on the ToRs as specified in the contract SoW.

Respective roles of the CIE reviewers and Chair are the PFMC's ToR for CPS Stock Assessment Methodology Review (see p. 6-8). The CIE reviewers will serve a role that is equivalent to the other panelists, differing only in the fact that they are considered 'external' members (i.e., outside the PFMC's membership and not involved in management or assessment of west coast CPS, particularly sardine). The reviewers will serve at the behest of the Chair, adhering to all aspects of the PFMC's ToR as described

in Annex 2. The Chair is responsible for: 1) developing an agenda; 2) ensuring that Panel members (including the Reviewers) and those being reviewed (the "proponents") follow the ToR; 3) participating in the review of the methods (along with the Reviewers); and 4) guiding the Panel (including the Reviewers), FRD, and NWSS to mutually agreeable solutions.

The Project Contact is responsible for any facility arrangements (e.g., conference room for Panel meetings or teleconference arrangements). The CIE Lead Coordinator can contact the Project Contact to confirm any meeting facility arrangements.

Contract Deliverables - Independent CIE Peer Review Reports: In addition to participating in the Panel, each CIE reviewer shall also complete an independent-review report in accordance with the SoW, i.e., in the required format as described in Annex 1; and addressing each ToR as described in Annex 2.

Other Tasks – Contribution to Summary Report: Reviewers will assist the Chair with contributions to the Summary Report. The Panel is not required to reach a consensus and, therefore, the reviewers should provide a brief summary of their views on the findings and conclusion reached by the Panel in accordance with the ToRs (format defined in Annex 1).

Specific Tasks for CIE Reviewer: The following chronological list of tasks shall be completed by the CIE reviewers in a timely manner, as specified in the **Schedule of Milestones and Deliverables**:

1) prepare for the review by thoroughly reading the documents provided by the Project Contact;
2) participate in the panel review meeting in La Jolla, CA during 3-5 February 2011 as indicated in the SoW, and conduct an independent review in accordance with the ToRs (Annex 2); and
3) write an independent-review report, addressed to the "Center for Independent Experts," and submit it to Mr. Manoj Shivlani, CIE Lead Coordinator, via email to, and CIE Regional Coordinator, via email to David Die ddie@rsmas.miami.edu, no later than 17 March 2011 indicated in the SoW. The report shall be written using the format and content requirements specified in Annex 1, and address each ToR in Annex 2.

Schedule of Milestones and Deliverables: The CIE shall complete the tasks and deliverables described in this SoW in accordance with the following schedule.

28 December 2011	The CIE sends the CIE reviewers' contact information to the COTR, who forwards it to the Project Contact.
10 January 2011	The Project Contact sends the pre-review documents to the CIE reviewers.
3-5 February 2011	The CIE reviewers participate in the Panel review meeting and conducts an independent review.
3 March 2011	The CIE reviewers submit their reports to the CIE Lead Coordinator and CIE Regional Coordinator for final review and revisions.
17 March 2011	The CIE submits independent peer review reports to the COTR for contractual compliance.
24March 2011	The COTR distributes the final reports to the Project Contact and the regional Center Director.

Modifications to the Statement of Work: Requests to modify this SoW must be made through the COTR who submits the modification for approval to the Contracting Officer at least 15 working days prior to making any permanent substitutions. The Contracting Officer will notify the CIE within 10 working days after receipt of all required information of the decision on substitutions. The COTR can approve changes to the milestone dates, list of pre-review documents, and ToR of the SoW as long as the role and ability of the Reviewer to complete the SoW deliverable in accordance with the ToRs and the deliverable schedule is not adversely impacted. The SoW and ToRs cannot be changed once the peer review has begun.

Acceptance of Deliverables: Upon review and acceptance of the reports by the CIE Lead Coordinator, Regional Coordinator, and Steering Committee, the reports shall be sent to the COTR for final approval as contract deliverables based on compliance with the SoW. As specified in the Schedule of Milestones and Deliverables, the CIE shall send via email the contract deliverables (the CIE independent peer review reports) to the COTR (William Michaels, via William.Michaels@noaa.gov).

Applicable Performance Standards: The contract is successfully completed when the COTR provides final approval of the contract deliverables. The acceptance of the contract deliverables shall be based on three performance standards: (1) the CIE report shall have the format and content in accordance with Annex 1; (2) the CIE report shall address each ToR as specified in Annex 2; and (3) the CIE report shall be delivered in a timely manner as specified in the schedule of milestones and deliverables.

Distribution of Approved Deliverables: Upon notification of acceptance by the COTR, the CIE Lead Coordinator shall send via email the final CIE reports in pdf

format to the COTR. The COTR will distribute the approved CIE reports to the Project Coordinator, the regional Center Director, and the PFMC.

Key Personnel:

William Michaels, Program Manager, COTR
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NMFS Project Contact:

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Annex 1: Format and Contents of CIE Independent Peer Review Report

1. The CIE report shall be prefaced with an Executive Summary providing a concise summary of the findings and recommendations.

2. The main body of the Reviewer's report shall consist of the following sections, in accordance with the ToRs: Background, Description of the Reviewer's Role in the Review Activities, Summary of Findings for each ToR, and Recommendations and Conclusion.

   a. The Reviewer should describe in their own words the review activities completed during the panel meeting, including providing a detailed summary of findings, recommendations, and conclusion.

   b. The Reviewer should discuss their independent views on each ToR even if these were consistent with those of other panelists, and especially where they were divergent.

   c. The Reviewer should elaborate on any points raised in the Summary Report that might require clarification.

   d. The Reviewer shall provide a critique of the review process, including suggestions for improving both the process and products.

   e. The CIE report shall be a stand-alone document for others to understand the proceedings and findings of the meeting without having to read the Panel report. The report shall be an independent review of each ToR, and shall not simply repeat the contents of the Panel report.

3. The Reviewer's report shall include the following separate appendices:

   Appendix 1: Bibliography of materials provided for review
   Appendix 2: The CIE Statement of Work
   Appendix 3: Panel Membership or other pertinent information from the review meeting.

Annex 2: Terms of reference (ToRs) for the peer review of the acoustic-trawl method for surveying Pacific sardine and other CPS

The CIE reviewers will participate in the panel-review meeting to conduct independent peer reviews of the acoustic-trawl method as it pertains to surveys of coastal pelagic fish species (CPS) in the California Current Ecosystem (CCE), principally Pacific sardine, but potentially also including jack mackerel, Pacific mackerel, and northern anchovy, depending on their biomasses and distributions, and the sampling effort afforded. The survey area is the CCE off the west coast of the United States of America (US), generally between the Mexico-US and the US-Canadian borders. The latitudinal and offshore extents of the surveys are seasonal, extending further north in the summer and further offshore in the spring. Survey estimates are to include absolute biomasses, and their total random sampling errors, and spatial distributions. The review solely concerns technical aspects of the survey design, method, analysis, and results, and addresses the following ToR:

ToR 1 – Review documents detailing acoustic-trawl survey and data analysis methods and results according to the PFMC's ToR for CPS Stock Assessement Methodology Reviews. Document the meeting discussions. Evaluate if the documented and presented information is sufficiently complete and represents the best scientific information available.

ToR 2 – Evaluate and provide recommendations on the survey method used to estimate the abundances and distributions of Pacific sardine and other CPS, and associated sources of uncertainty. Recommend alternative methods or modifications to the proposed methods, or both, during the Panel meeting. Recommendations and requests to FRD for additional or revised analyses during the Panel meeting must be clear, explicit, and in writing. Comment on the degree to which the survey results describe and quantify the distributions and abundances of CPS, in particular Pacific sardine, and the uncertainty in those estimates. Confidence intervals of survey estimates could affect management decisions, and should be considered in the report.

ToR 3 – Evaluate and provide recommendations for the application of these methods for their utility in stock assessment models and for their ability to monitor trends at the population level for Pacific sardine and other CPS. Survey methods or results that have a flawed technical basis, or are questionable on other grounds, should be identified so they may be excluded from the set upon which stock assessments and other management advice is to be developed.

ToR 4 – Evaluate the effectiveness of the survey methods for detecting the appropriate spatial scale and seasonal timing for annually estimating stock abundances.

ToR 5 – Decide through Panel discussions if the ToRs and goals of the peer review have been achieved. If agreement cannot be reached, or if any ToR cannot be accomplished for any reason, then the nature of the disagreement or the reason for not meeting all the ToR must be described in the Summary and Reviewer's report. Describe the strengths and weaknesses of the review process and Panel recommendations.

The Reviewer's report should be completed, at least in draft form, prior to the end of the meeting.

Annex 3: Tentative Agenda

THURSDAY, FEBRUARY 3, 2011 – 8:00 A.M.

A. Call to Order, Introductions, Approval of Agenda, and Appointment of Rapporteurs

B. Terms of Reference for the CPS Methodology Reviews
(8:30 a.m., 0.5 hour)

C. Presentation on the acoustic-trawl survey David Demer
(9:00 a.m., 1.5 hours)

BREAK

C. Presentation on the acoustic-trawl survey (Continued) David Demer
(11 a.m., 1 hour)

LUNCH

C. Presentation on the acoustic-trawl survey (Continued) David Demer
(1 p.m., 1.5 hours)

D. Panel discussion Panel
(2.30 p.m., 1 hour)

BREAK

E. Requests to FRD Panel
(4.00 p.m., 1 hour)

FRIDAY, FEBRUARY 4, 2010 – 8:30 A.M.

F. Responses to Panel Requests (FRD) David Demer
(8.30 a.m., 2 hours)

BREAK

G. Panel discussion Panel
(11 p.m., 1 hour)

LUNCH

H. Requests to the FRD Panel
(1 p.m., 1 hour)

I. Report drafting Panel
(2.30pm, 1 hours)

BREAK

J. Responses to Panel Requests (FRD) David Demer
(4 p.m., 0.5 hours)

K. Requests to FRD Panel

(4.30 p.m., 0.5 hours)

SATURDAY, FEBRUARY 5, 2010 – 8:30 A.M.

K. Responses to Panel Requests (FRD) David Demer
(8.30 a.m., 1.5 hours)

BREAK

L. Report Drafting Panel
(11am , 1 hours)

LUNCH

M. Report review Panel
(1 p.m+)

Annex 4: Panel Summary Report (Template)

- Names and affiliations of Panel members

- List of analyses requested by the Panel, the rationale for each request, and a brief summary of the proponent's responses to each request.

- Comments on the technical merits and/or deficiencies in the assessment and recommendations for remedies.

- Explanation of areas of disagreement regarding Panel recommendations:
  - among Panel members; and
  - between the Panel and the proponents

- Unresolved problems and major uncertainties, e.g., any special issues that complicate survey estimates, estimates of their uncertainty, and their use in stock assessment models.

- Management, data, or fishery issues raised the public (i.e., non-Panel and proponent participants) at the Panel meetings.

- Prioritized recommendations for future research, and data collections and analyses.

Appendix 3: Panel Membership or other pertinent information from the review meeting.

Andre Punt (PFMC, Chair)	aepunt@u.washington.edu
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Mike Burner (PFMC)	Mike.Burner@noaa.gov
Observers and SWFC/FRD	
Bill Michaels (NMFS)	
Russ Vettor (NMFS)	